Run Time Assurance Methods Applied to Advanced Propulsion Algorithms - SBIR PHASE III

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Glenn Research Center Contract No. NNC12CA12C

National Aeronautics and Space Administration

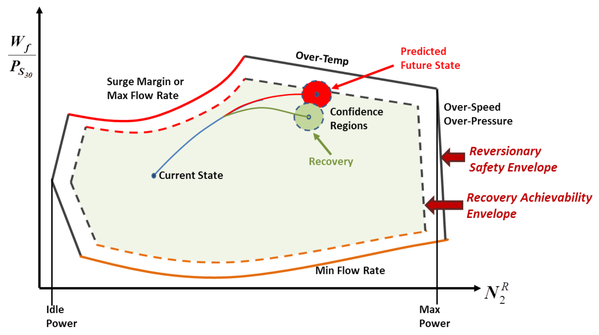
Description

As the complexity of control systems grows, the cost associated with verification and validation (V&V) has increased exponentially - making the certification of such complex systems prohibitive. Currently, there is wide interest in run time assurance (RTA) systems that monitor the complex controllers during operation and revert to backup, pre-certified control when "unsafe" operation by the advanced system is identified. This effort is investigating the efficacy of RTA for advanced engine control.

Benefits

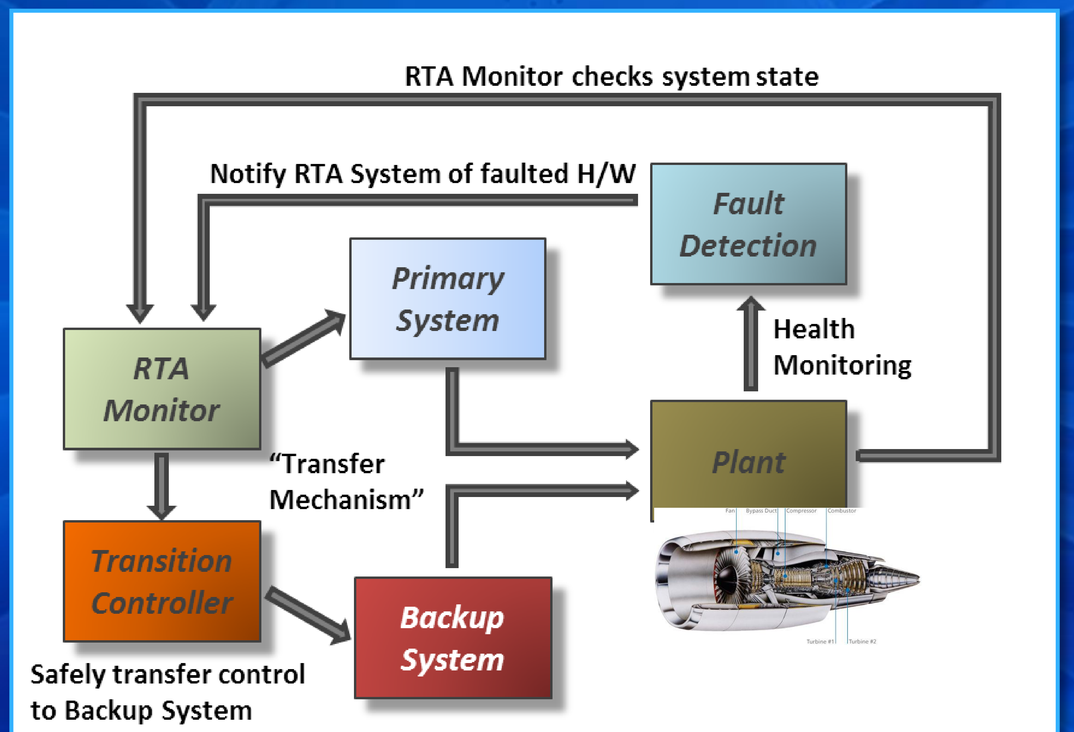
The use of RTA for advanced engine controllers will allow for safe operation of the advanced systems by combining limited off-line V&V with on-line monitoring. The "push" is for this approach to be accepted by the certification authorities and defined V&V protocols.

Example Defined Safe Operating Region



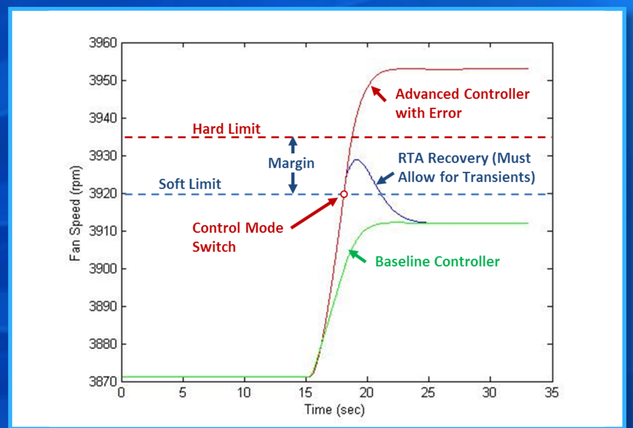
Approach

NASA provided a Matlab/Simulink model for an advanced Kalman filter parameter estimation routine and closed loop engine controller applied to the Commercial Modular Aero-Propulsion System Simulation 40k (C-MAPSS40k). The advanced controller directly feeds back an estimate of thrust to control thrust directly, rather than indirectly through other sensed engine parameters. A previously developed RTA system for an advanced autoland controller is being applied to this advanced engine controller. A main effort in the first year of the program was to identify safe operating regions for known and measurable engine parameters , such as fan speed and engine pressure ratio (EPR). Once the RTA system identifies that one or more of these parameters is close to its pre-defined limit for the current operating point, control is switched to a baseline EPR feedback system.



Recent Results

Current results indicate the benefits of employing an RTA system for advanced engine controllers. In one experiment, errors were seeded into the Kalman filter causing fan speed and other engine parameters to exceed their limits if no run time monitoring is utilized. With the RTA system active, control is switched to the baseline system and these parameters return to their expected values.



Future Work

In the second year of the project, the RTA system will be applied to the full nonlinear engine model with the control system for the complete operating envelope. Safe operational envelopes will be further defined and developed and experiments performed using more complex, possibly multi-dimensional safety envelopes.

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